DOCUMENT RESUME

ED 037 374 SP 001 513

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| TITLE | Toward a Model of Teacher-Learner Interaction. |
| INSTITUTION | Stanford Univ., Calif. Stanford Center for Research and Development in Teaching. |
| SPONS AGENCY | Office of Education (DHEW), Washington, D.C. Bureau of Research. |
| REPORT NO | RM-18 |
| BUREAU NO | BR-5-0252 |
| PUB DATE | Jan 68 |
| CONTRACT | OEC-6-10-078 |
| NOTE | 16p. |
| EDRS PRICE | EDRS Price MF-$0.25 HC-$0.90 |
| DESCRIPTORS | *Classroom Communication, *Cognitive Processes, Learning Characteristics, *Learning Theories, *Models, Stimulus Generalization, Student Behavior, *Student Teacher Relationship, Teacher Behavior, Teaching Skills |

ABSTRACT

A model of informational interaction between teachers and learners has been developed and the first facet for its taxonomy derived. The model focuses on the internal cognitive events of teaching and learning in human beings generally, rather than on the specific roles of instructor and student. Teacher-learner communication is described in terms of mathemagenic behaviors (teaching and learning skills) which intervene between nominal stimuli (e.g., a printed page or a teacher's behavior) and the representation of these stimuli in the learner or teacher (effective stimuli). The model depicts a dual control system in which teacher and learner operate in tandem through a continuous process of feedback and regulation (the regulatory behaviors constituting teaching and learning styles or aptitudes). Levels of mathemagenic behavior appear to exist in hierarchical relation to each other within an individual with distinctions made between perceptual and higher level cognitive processing, etc. It appears possible to infer the levels of processing involved in a given interaction from analyses of such data as learner, observer, and teacher perceptions and teacher and learner skills. Experimental studies already performed suggest that mathemagenic behaviors characterized by probing, higher order questioning, and translation development can be identified in and acquired by teachers. Further research needs to investigate parallel learner behaviors. (JS)

STANFORD CENTER FOR RESEARCH AND DEVELOPMENT IN TEACHING

Research Memorandum No. 18

# TOWARD A MODEL OF TEACHER-LEARNER INTERACTION

by

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January 1968

# TOWARD A MODEL OF TEACHER-LEARNER INTERACTION

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In an earlier paper (Snow, 1967), an approach to research on teaching based on the metatheoretical and methodological views of Brunswik and Guttman was outlined. An application of Brunswik's lens model suggested the value of idiographic analyses of teaching and learning in terms of observed behavioral cues and inferred personal traits. Guttman's facet model was seen as facilitating the construction of a taxonomy of such variables. Both positions in turn supported a cognitive, information-processing view of teaching-learning processes. The purpose of the present paper is to further this thinking. Specifically, a preliminary model of informational interaction between teachers and learners is attempted and a first facet for the taxonomy is derived. Data relevant to both developments are discussed.

Before further steps in model construction can usefully be taken, a rather basic assumption concerning the nature of the phenomena in question deserves explication. It is believed that the importance of this assumption for research on teaching has not been sufficiently recognized in the past.

The event called teaching can be defined as a social act; a communicative interaction between two or more human beings, one of whom may be termed an instructor, the others being termed students. Because teaching can be viewed as social interaction, it is too easily viewed only as that. Through human need for symmetry, learning also comes to be regarded as basically an interpersonal phenomenon. As emphasized by Gagne (1966, p. 112) however, "...learning is not a social interaction, but rather an intra-cranial event. It takes place within the nervous system of the learner, and not by any means outside it". It is suggested that much of what is called teaching should also be characterized as intra-cranial and that teaching and learning are frequently interchangeable as roles, perhaps even as processes. An exact symmetry between intrapersonal teaching and learning processes is as unlikely as is the interpersonal symmetry rejected above. But teachers do learn and learners do teach; it can be assumed that virtually all human beings do both

almost simultaneously and further that many can perform teaching functions for their own learning processes. The model sought here, therefore, focuses on the internal cognitive events of teaching and learning in human beings generally, rather than on the specific roles of instructor and student.

## Process Components

As a preliminary organization of the model, it will be useful to consider the characteristics of information processing in a two-person system. While related in part to the work of Smith (1960) and Ryans (1963), the present approach draws more directly on a discussion by Fitts (1964) of informational models in research on perceptual-motor skill learning. Fitts distinguishes among communication models, control system models and adaptive system models, but notes that a given application frequently combines all three types. An accumulation of the three seems appropriate here. The complete model is schematically represented in Figure 1. Its details are discussed below.

Communication. The transmission of information between teacher and learner may best be understood in terms offered by Rothkopf (1965). Rothkopf's research concerns learning from written instruction, but his formulation can readily be extended to two-way communication between individuals. He defines a class of learner-based behaviors which intervene between the physical stimuli of a printed page or a teacher's behavior (nominal stimuli) and the representation of these stimuli in the learner (effective stimuli, or stimuli-as-coded). It is clear that the nature of effective stimulation is a function of intervening internal learner behaviors, that this nature varies across learners and across time within learners, and, ultimately, that it is the effective rather than the nominal stimuli which underly learned associations, structures, etc. Rothkopf calls these intervening processes "mathemagenic behaviors" (literally, behaviors which give birth to learning), although formerly the more restrictive term "inspection behaviors" was used. They include attentional changes such as gross postural adjustments of the head and body and eye movements as well as several classes of typically unobservable information processing activities identified as translation, segmentation, review, mnemonics, etc. Rothkopf emphasizes further that these behaviors must be considered as either consistent or inconsistent with instructional objectives in a given instance.

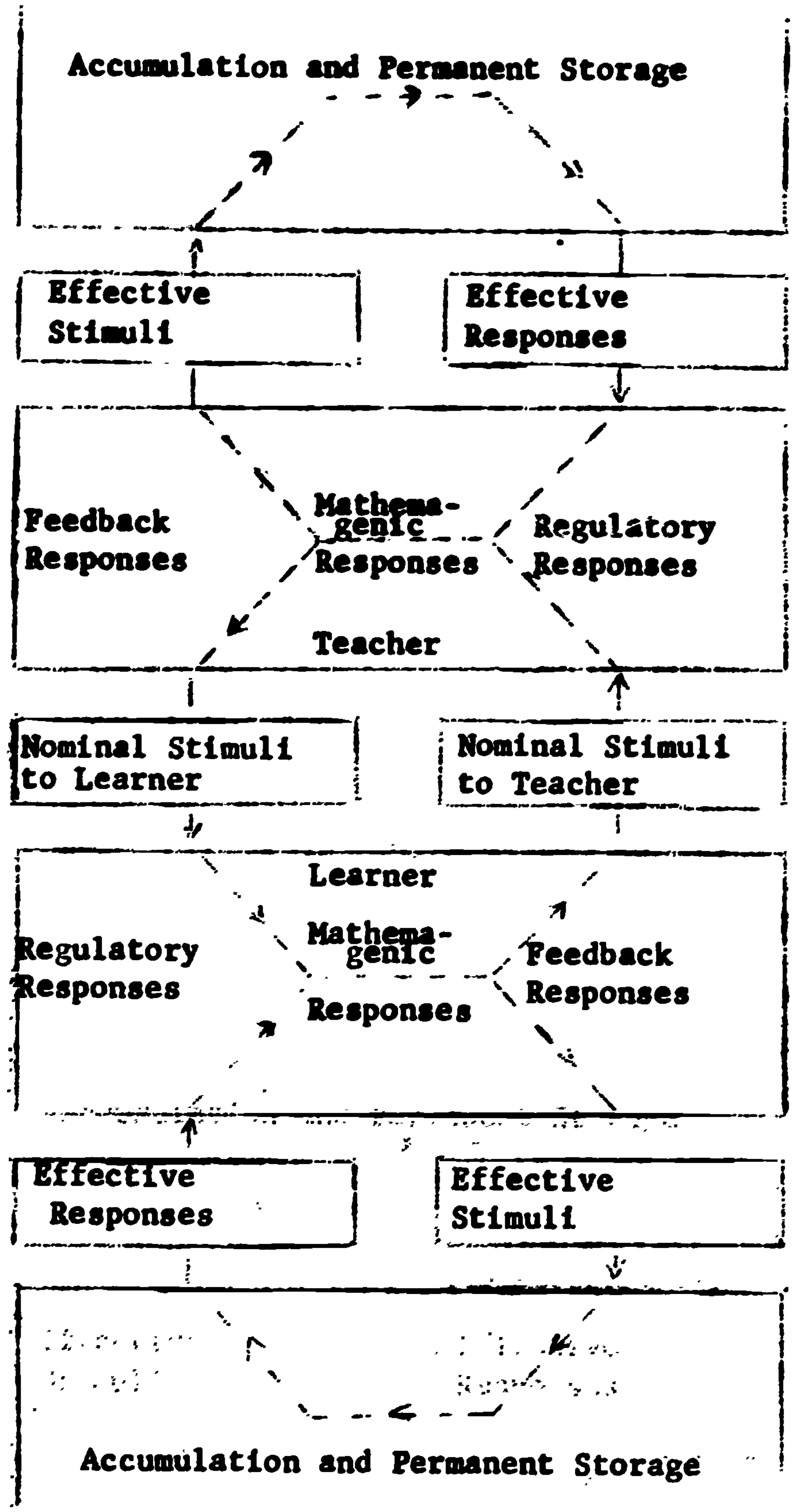


Fig. 1. Information-Processing Model of Teaching-Learning Interaction Emphasizing Mathemagenic Behaviors of Teacher and Learner.

Although the concept of mathemagenic behavior seems particularly useful in the study of higher cognitive processes, Rothkopf's (1965, pp. 200-201) emphasis has so far been principally on the analysis of attention phenomena:

> The critical assumption about each of these functional classes of mathemagenic responses is that it has topography, rate characteristics, and persistence, and that these attributes can be modified or altered by certain environmental events . . . There are also strong grounds for suspicion that some of the most interesting changes in mathemagenic behavior involve changes in the stimulus control of this behavior. These stimulus controls functionally resemble attention.

For Rothkopf, the stimulus controls of interest reside in the nominal stimuli of the printed page. Once a learner has been committed to a given document, these controls are fixed. In interpersonal communication, particularly in classrooms, the field of nominal stimulation is dominated by a teacher's behavior, which is potentially variable as a function of nominal stimuli provided by the learner. Of the three attributes of mathemagenic behavior mentioned by Rothkopf, "topography" is seen as the general term. "Rate characteristics" and "persistence" both describe the "temporal" topography of classroom behavior. The former is an aspect of teacher behavior and, hence, of the nominal stimuli to the learner. The latter is an aspect of learner behavior and, hence, of the nominal stimuli to the teacher. By way of further definition, the topography of behavior refers to the pattern or configuration of responses and, hence, to both simultaneous and sequential patterns. It suggests a map showing the relative positions and elevations of responses on theoretically relevant dimensions. Since the communication system operates in both directions, it is necessary to include both teacher and learner mathemagenic behavior in the model and to consider the dual nature of the variable control system.

Control. In the learner, some of the results of mathemagenic changes presumably affect subsequent behavior. These can be viewed as feedback responses within the individual. Their immediate and enduring effects are regulatory responses which moderate ongoing information processing. The more enduring regulatory behaviors might better be referred to as teaching and learning styles or as aptitudes; they are observable to some extent through measures of individual differences taken before or during teaching and learning.

Some aspects of learner mathemagenic behaviors also provide feedback to a teacher and/or an observer. Those which are observed represent nominal stimuli to the teacher to be used as cues for inferred learner behaviors. In the teacher, a set of mathemagenic processes comparable to those of the learner can be presumed to exist. Here, however, the control system must have as an additional characteristic a kind of comparison with some desired standard. Through a continuous process of feedback and regulation, teacher and learner operate in tandem, with the teacher seeking to optimize the transfer function obtaining between teacher input and observed learner output. This desired standard can be conceived as an intermediate instructional objective. It will be assumed here that this objective is to obtain and maintain a maximal level of cognitive processing on the part of learners. It is reasonable to assume that the learner's behavior also involves some comparison with a standard, seeking to optimize the same or similar function. Other interesting functions can also be imagined: minimization of the time required for comprehension or maximization of the number of overt participations given in a class period, etc. It is possible also to consider teaching as a process of Bayesian estimation of a learner's cognitive level through a series of data samplings and interchanges between teacher and learner. The implications of viewing the teacher as a Bayesian cannot be pursued here, however.

Rothkopf's reference to stimulus control is related to a distinction suggested above concerning the immediacy of regulatory-feedback processes. To the extent that teacher-learner interaction is under stimulus control, the regulatory-feedback process is immediate, and the information flow follows the inner octagonal path of arrows depicted in Figure 1. Relatively central control, as opposed to stimulus control, is implied by the involvement of outer paths and components in the regulatory-feedback process. The teacher's role as the start of an interaction might be characterized as first, using stimulus control to disengage a learner's central processes from extraneous activity (or inactivity), and second, transferring this control to direct connection between the two central processes. Separate teaching skills related to the use of stimulus and central control might profitably be identified; both would involve a third skill of monitoring feedback cues while remaining free of learner-generated or other distractions. Still others might concern the effecting of appropriate transitions between the two phases.

The relativity of the stimulus vs. central control distinction should be noted since all behavior is presumed to involve varying degrees of both. But the contrast is important because it implies related contrasts between perceptual and conceptual curiosity, and extrinsic and intrinsic motivation (see Berlyne, 1965). In turn, the members of each of these pairs seem to be differentiable in terms of a general process level dimension. Each implies a different response pattern or response topography.

Adaptation. An information storage component has already been implied. The system is made adaptive, in both a short-term and a long-term sense, by assuming the operation of memory in both teacher and learner. No attempt has been made, however, to elaborate the detailed characteristics of this aspect of the model. As the emphasis of Figure 1 suggests, the present concern is with the relatively immediate or short-term interactions involved in teaching and learning. The dynamics of longer-term accumulation of associations, structures, etc. have not been considered except as these phenomena may be represented as moderator or regulatory variables.

## Process Levels

Having outlined a model of relevant information processing characteristics of teachers and learners, it is now possible to consider the organization of the processes themselves and the structure of their interaction in sequences of behavior. In this way it is hoped that some general dimensions for classifying teaching and learning behaviors might be defined.

Hierarchical organization. It was suggested earlier that the mathemagenic behaviors described by Rothkopf might differ in terms of an underlying dimension reflecting the level of information processing required or implied by each. That is, some mathemagenic behaviors are presumed to involve only minimal processing commitment: auditory monitoring of a teacher's behavior while one's eyes and thoughts are elsewhere clearly signifies a lower level of commitment than would general orienting responses toward the teacher as a stimulus source. On the other hand, internal review of received information would suggest a level of processing higher than either of these, while translation of such information into synonymous terminology would represent a still higher commitment level. In general, the dimension as so-far conceptualized extends from a lowest level where the stimuli in question are totally ignored,

and where increases in level can be effected only through obtaining stimulus control, to a highest level where central control predominates. The latter reaches of the proposed dimension may be referred to as the traditional "higher cognitive processes". These levels are here thought, however, to combine both cognitive and affective interpretation in the more general terminology of processing commitment or engagement rather than being restricted to one or the other of the traditional domains.

The levels would appear to exist in hierarchical relation to one another within an individual. With a learner beginning at rest, stimulus control by a teacher would be prerequisite to attaining central control. Presumably, a first major subdivision of the dimension into upper and lower levels can be made using the distinctions between perceptual and conceptual curiosity and between extrinsic and intrinsic motivation suggested in an earlier section. Beyond this, however, it should be possible to make finer distinctions between levels. Since a similar hierarchical conception has been used by several other investigators in recent years, it may be possible to base present efforts on the earlier work, adapting or combining terminology wherever possible. Of particular note in this regard are the taxonomic systems suggested by Gagne's (1965) types of learning, the cognitive domain of Bloom _et al_ (1956), the affective domain of Krathwohl _et al_ (1964) and the product dimension of Guilford's structure of intellect model (1967).

In Figure 2, a rough map of process levels for both teachers and learners is presented. It includes some preliminary designations for different levels and areas, but these are meant to be only suggestive at this point. As shown, the lower ranges of the dimension have been stratified using the terms "ignoring", "monitoring", "orienting", "attending", "receiving" and "responding" while the upper levels have been combined as "higher productive processing".

No completely satisfactory set of labels for the various levels can be offered at present, nor need they be. It will be sufficient to recognize the dimension as a continuum and to determine if it serves to make useful distinctions within the behavior of given teachers and/or learners, or to guide research on such behavior. An important task for research in fact would be to seek better definition for the dimension and its several levels.

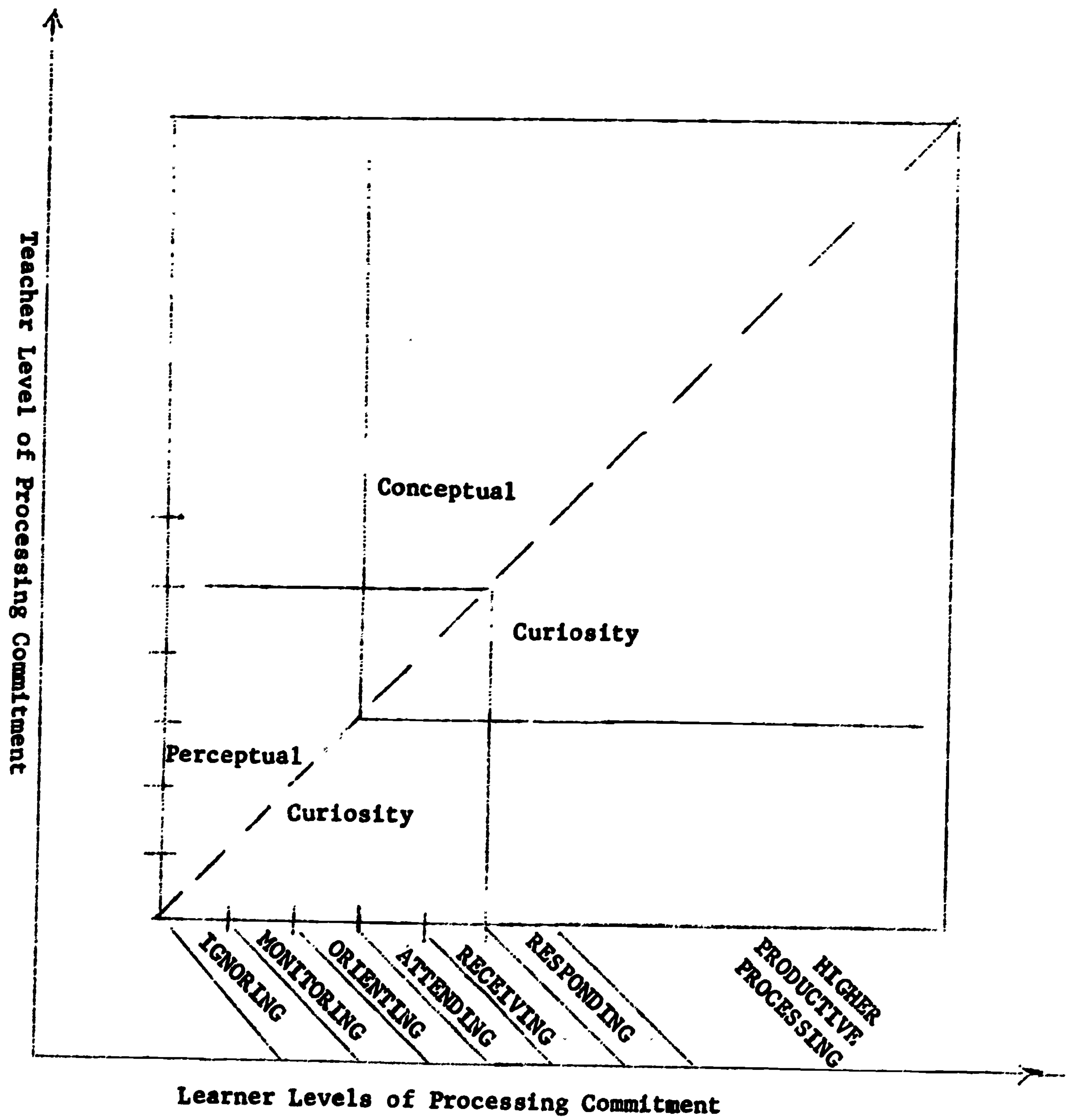


Fig. 2. A Preliminary Map of Process Level Dimensions for Teachers and Students.

Related Research and Design. Process level dimensions can be presumed to affect both nominal and effective stimuli in both teachers and learners. It should be possible, then, to infer the levels of processing involved in a given interaction from analyses of several kinds of data. The types of data obtainable for such analyses are suggested in Figure 3.

Teacher, learner and observer perceptions may be collected systematically using rating scales and other questionnaire devices and treated by conventional correlational or multidimensional scaling methods. Note, however, that each kind of data represents the informational system from a different point of view. One would not expect results based on different sources to be coincident; in fact, significant differences between sources would provide important information about the system. Similarly, differences in results for data arising from the same source might be expected when systematically varying groups of subjects are used. An example of this latter approach to research on the model is provided by an investigation conducted by Yee[1]. A 100-item inventory designed to collect student attitudes about their teachers' classroom behavior was administered in 102 classrooms in middle socio-economic level schools and in 110 classrooms in lower socio-economic level schools. While all results of the study are not in hand as yet, it is possible to extract some patterns of correlations that bear relevance to the present model. From class means on the items, Yee formed several composite scores to represent factors obtained in previous factor analyses of the same and similar data (see Beck, 1964, and Yee, 1965). Correlations among seven of these composites, computed separately for middle and lower class schools, are shown in Table 1. It can be seen that the correlations assume a rough simplex structure for four of the factors in both samples, as a single hierarchy hypothesis would suggest. The progression of factor identifications (the wording was formulated by Yee without knowledge of the hierarchical hypothesis) conforms roughly to the levels of commitment dimension as conceptualized in the present paper. It is especially suggestive that the simplicial progression extends through factors $P_{10}$ and $P_{11}$ for the middle class schools, while disintegrating beyond factor $P_5$ for the lower class schools. Note that the factors excluded from the lower class

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[1]A. H. Yee, Personal communication, January 12, 1967..

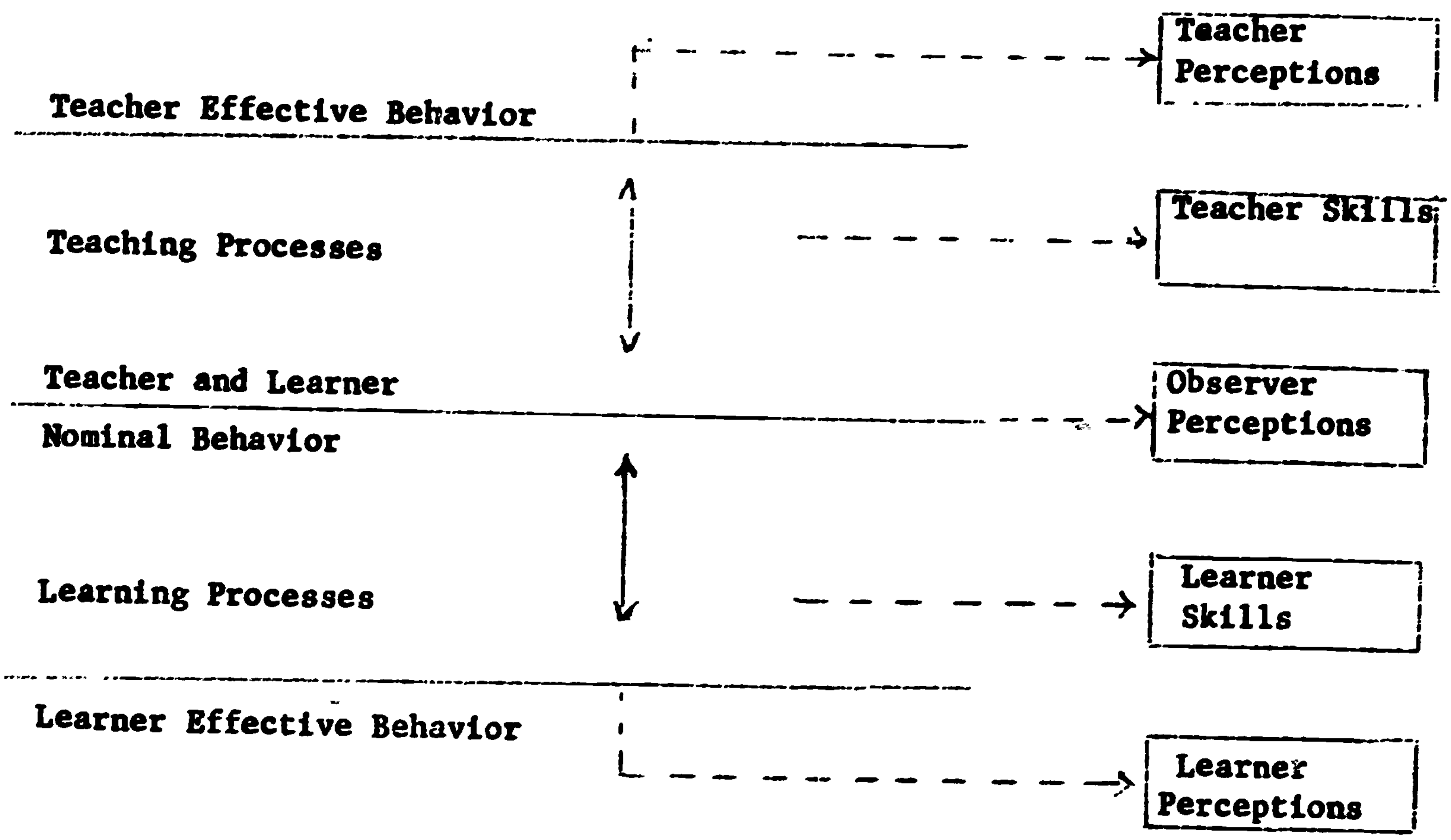


Fig. 3. Categories of Data Available from Different Points in the Model.

hierarchy of perceived teacher behaviors relate to higher-order levels of commitment. Yee's terms "encourage", "inspire", and "interested" are especially to be noted in this regard. Comparative results from teachers and observers in the same classrooms would be most enlightening.

Additional types of data would arise from experimental manipulation of teacher and/or learner mathemagenic behaviors, more conventionally referred to as skills. Several recent studies have focused on particular teaching skills designed to change the learner's level of cognitive processing in classroom participation. Orme, McDonald and Allen (n. d.) defined a skill called "probing" in which a teacher uses questioning techniques to force learners beyond first-answer responses. Presumably more remote and more complex associations and structures are stimulated in the learner; a higher level of processing is implied. Several subclasses of probing behaviors have also been delineated. Among these are: clarification, increased critical awareness, refocus, prompting, encouraging alternatives and redirection. In another study, Berliner, McDonald, Sobol and Allen (1967) provided definition for another skill designed to alter the learner's processing level. This teaching behavior, called "higher-order questioning", seeks to promote idea manipulation and inferential processes in place of simple recall or description of ideas by the learner. Both the probing and the questioning study have demonstrated that these skills can be acquired through suitably designed training conditions, and that independent observers can identify and rate these behaviors reliably in teachers. A third study by Millett[2], now in progress, has sought to analyze further the kinds of teaching and learning behaviors elicited by probing and questioning strategies. He defined a teaching strategy called "translation development" including such behaviors as directing learners to translate communications into their own words, questioning designed to elicit translation, probing, hinting, restatement and silence. Following different teacher training conditions, he then recorded the verbal interactions of classroom discussion, demonstrating that both teacher and learner components of these interactions could be reliably coded as instances of translation behavior. Table 2 presents means for both teachers and learners in the four training conditions as well as mean performances

[2] G. B. Millett, Personal communication, April 3, 1967

## TABLE 1

Correlations Among Seven Composite Student Scores For Middle and Lower Socio-Economic Class Teachers.

**Lower Class Teachers N=110**

| | $P_6$ | $P_7$ | $P_2$ | $P_5$ | $P_{11}$ | $P_{10}$ | $P_8$ |
|---|---|---|---|---|---|---|---|
| $P_8$ | 13 | 18 | 15 | 23 | -16 | -03 | |
| $P_{10}$ | 13 | 16 | -01 | 02 | 17 | | |
| $P_{11}$ | 10 | 20 | 16 | 16 | | | |
| $P_5$ | 35 | 56 | 85 | | | | |
| $P_2$ | 46 | 55 | | | | | |
| $P_7$ | 53 | | | | | | |
| $P_6$ | | | | | | | |

**Middle Class Teachers N=102**

| $P_6$ | $P_7$ | $P_5$ | $P_2$ | $P_{11}$ | $P_{10}$ | $P_8$ | |
|---|---|---|---|---|---|---|---|
| 12 | 12 | 17 | 17 | 16 | 17 | | $P_8$ |
| 40 | 38 | 38 | 45 | 53 | | | $P_{10}$ |
| 46 | 53 | 64 | 61 | | | | $P_{11}$ |
| 54 | 67 | 85 | | | | | $P_2$ |
| 56 | 79 | | | | | | $P_5$ |
| 74 | | | | | | | $P_7$ |
| | | | | | | | $P_6$ |

WHERE:

| | | |
|---|---|---|
| $P_8$ | Teacher use of innovations, A.V. aids, etc. | $P_8$ |
| $P_{10}$ | Pupils' perception of teacher's ability to encourage and inspire pupils to be interested in learning (positive items) | $P_{10}$ |
| $P_{11}$ | Pupils' perception of teacher's ability to encourage and inspire pupils to be interested in learning (negative items) | $P_{11}$ |
| $P_5$ | Pupils' perception of teacher effectiveness in explaining ability, communication (positive items) | $P_2$ |
| $P_2$ | Pupils' perception of teacher personal popularity and warmth | $P_5$ |
| $P_7$ | Pupils' perception of teacher's disciplining behavior | $P_7$ |
| $P_6$ | Pupils' perception of own discipline | $P_6$ |

on a short-answer written translation test administered following the classroom discussions. Although analyses of these data are not yet completed, raw differences between the training conditions and the correlation between teacher and learner discussion behavior are striking. Also noteworthy is the absence of any lasting training effect in the written test performance.

Taking these and other experimental studies together, it seems clear that mathemagenic behaviors characterized as probing, higher-order questioning and translation development can be identified in and acquired by teachers. Their use holds some promise of influencing complementary mathemagenic behavior in learners. It is suggested that the process level dimension can be used to conceptualize such mathemagenic behaviors as existing in an organized hierarchy and to suggest those levels of teacher processing that are likely to be involved in a given level of learner processing. The dimension should be useful as a guide for criterion development in future experiments and for pattern analysis in future correlational studies.

## Implications

The present paper has gone only a short distance toward the development of an adequate conception of teacher-learner interaction. The most pressing need for further research, on which additional model development will depend, is to investigate the learner behaviors associated with teacher skills and perceived teacher behaviors. The implications of ideas and data reviewed here, though they are only suggestive at present, are that teacher behaviors can be shown to influence the overt manifestations of mathemagenic behaviors in the learner but it is possible that learners can also provide some of these teaching behaviors for themselves or for each other. Classroom interactions like discussion probably facilitate learning for all learners present, not just those who participate, and one can engage in translation behavior overtly or covertly with or without teacher stimulation. In short, teaching should be studied in terms of its effects on mathemagenic behavior and mathemagenic behavior should be studied in terms of its effects on learning. Direct teaching-learning relationships may not be demonstrable, and perhaps should not be expected.

TABLE 2

Average Translation Performances For Teachers and Learners In Four Training Treatments

| Teacher Training Treatment | Teacher Translation Frequency | Learner Translation Frequency | Learner Translation Test Score |
|---|---|---|---|
| General Discussion n=11 | .91 | .27 | 6.93 |
| Verbal Description of Translation Behavior n=10 | 12.90 | 5.70 | 6.45 |
| Demonstration of Translation Behavior by Video Tape n=10 | 11.20 | 5.20 | 6.92 |
| Both Description and Demonstration n=8 | 26.38 | 10.88 | 5.54 |

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